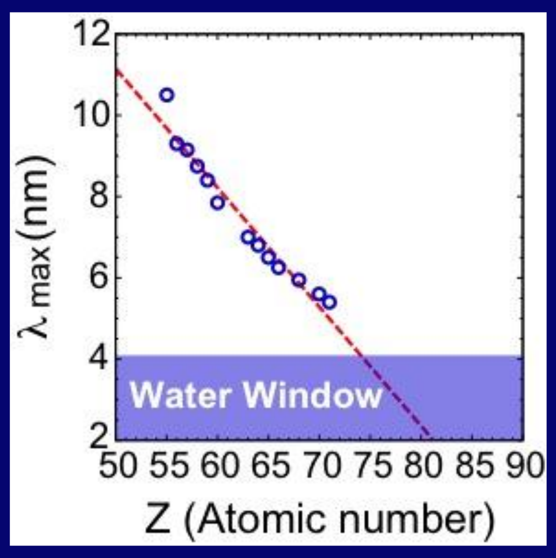

Possibility of high-*Z* plasma water window sources

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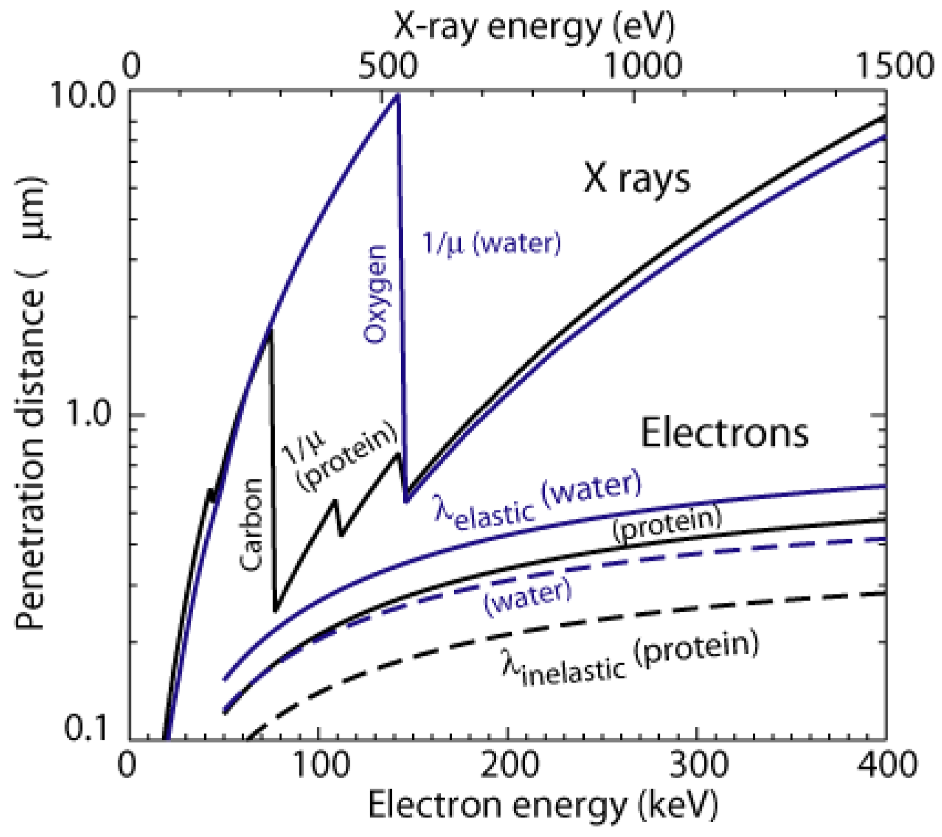
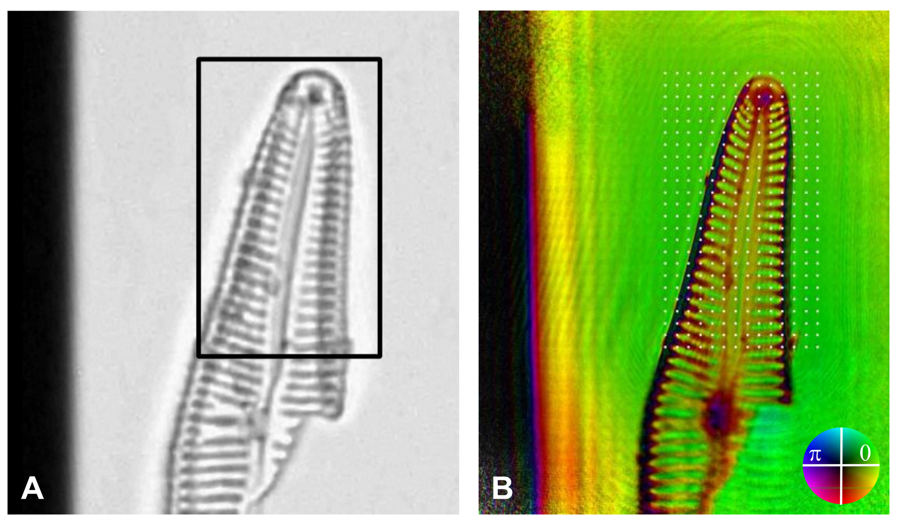
1. Introduction

Soft X-rays have a photon energy of 100-1000 eV, or a wavelength of about 1-10 nm. Their wavelength gives the potential for high-spatial resolution imaging. The photon energy is well matched to the inner-shell electron binding energy in low-Z elements. This provides very good intrinsic contrast between organic material and water in the "water window" between the K edges of carbon and oxygen, and good penetration in micrometer-thick specimens.



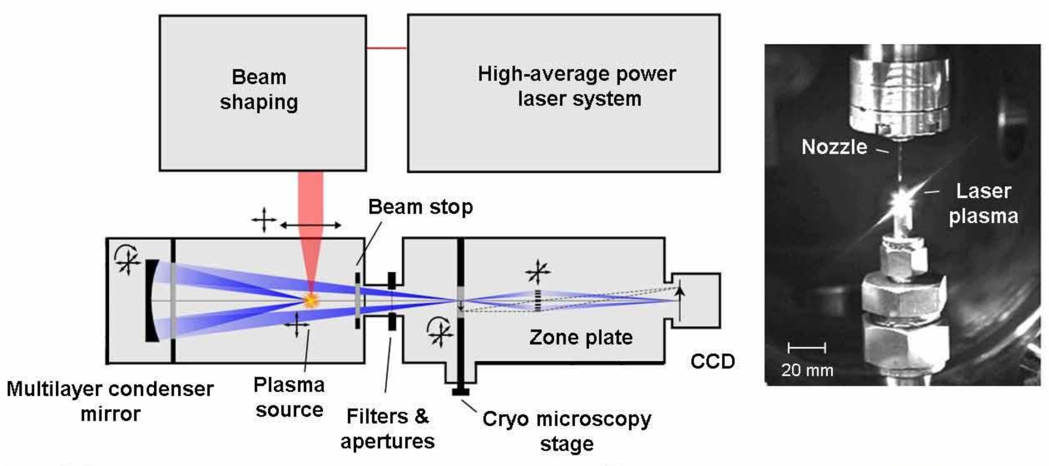
http://xray1.physics.sunysb.edu/research/intro.php



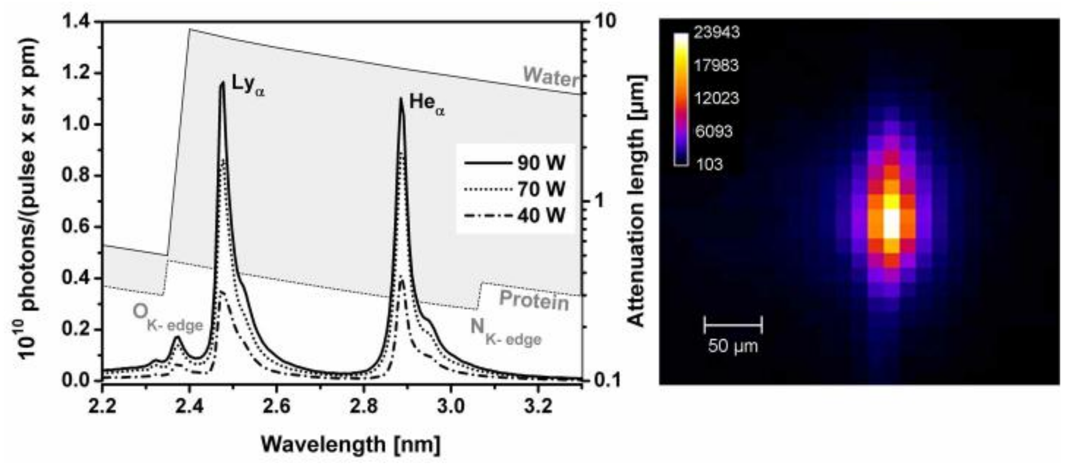
(A) Optical micrograph of a fossil diatom sample. The area scanned by the x-ray beam is marked by a black frame. (B) Complex-valued ptychographic reconstruction of the object transmission function from the same diatom sample as shown in subfigure A.

K. Giewekemeyer et al., Opt. Exp. **19**, 1037 (2011).

The arrangement and optical layout of a table top water window x-ray microscope.
The bandwidth at 2.478 nm is 0.008 nm (FWHM) with a peak reflectivity up to 0.4 %.

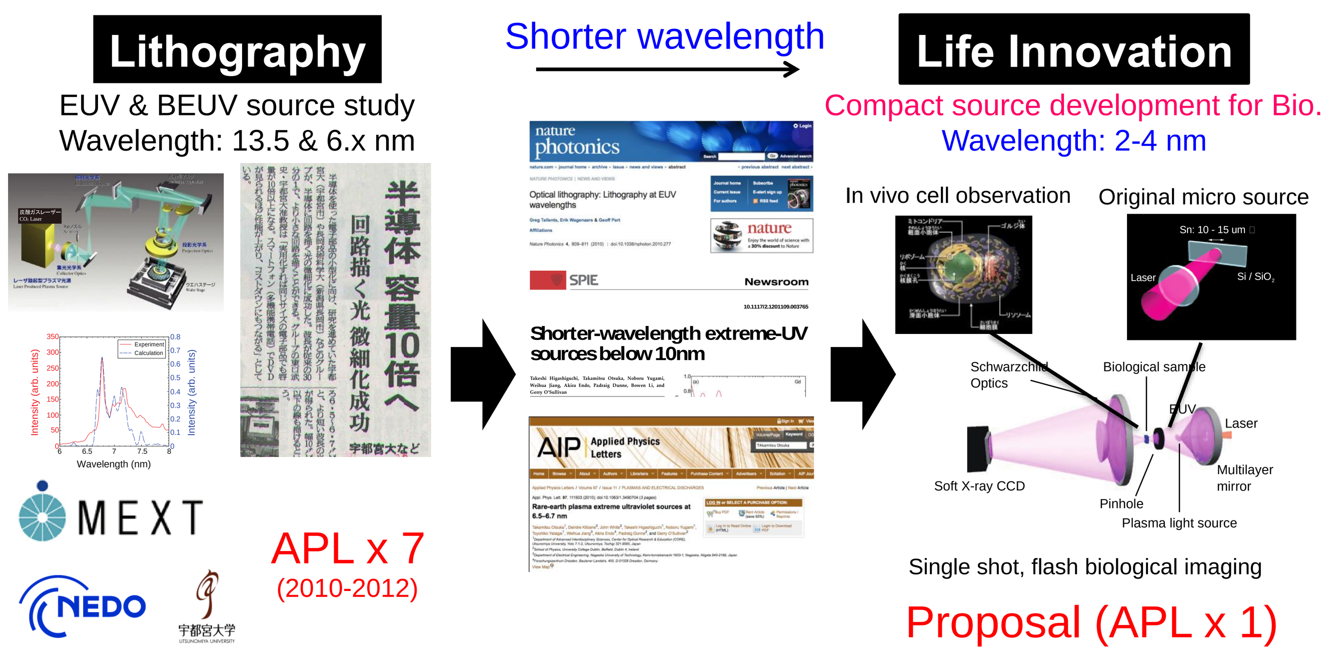


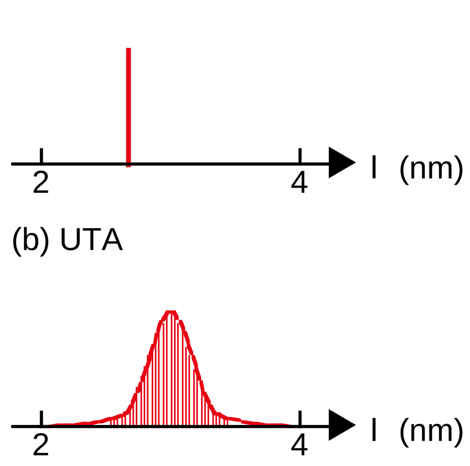
On the left: Emission spectra of a liquid-nitrogen plasma. On the right: Measured x-ray beam size at the focus of the condenser multilayer mirror at a laser power of 60 W.



H. Legall *et al*., Opt. Exp. **20**, 18362 (2012).

Our objective is the demonstration of a high-brightness, high energy EUV/soft x-ray ***Flash*** source in the water window (3.2 nm) based on knowledge of the behavior of 13.5-nm EUV & 6.x-nm BEUV sources.





2. Experimental and numerical results

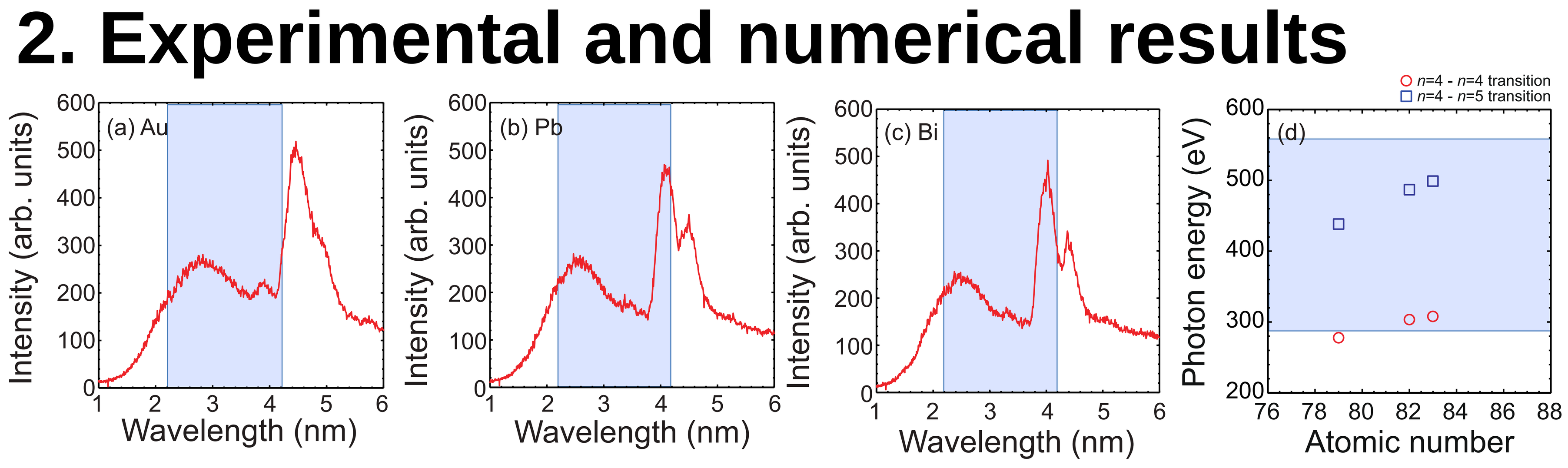
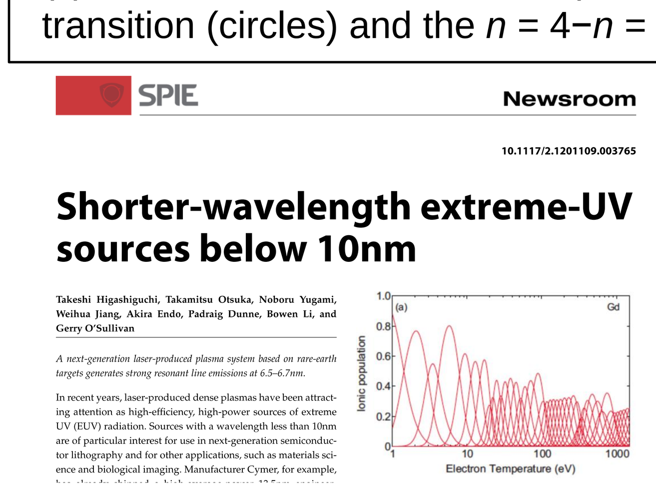


Fig. 1. Time-integrated spectra from picosecond-laser-produced high-*Z* plasmas of Au (a), Pb (b), and Bi (c), and the atomic number dependence of the photon energies of peak emission of the n = 4−n = 4 transition (circles) and the n = 4−n = 5 transition (rectangles).



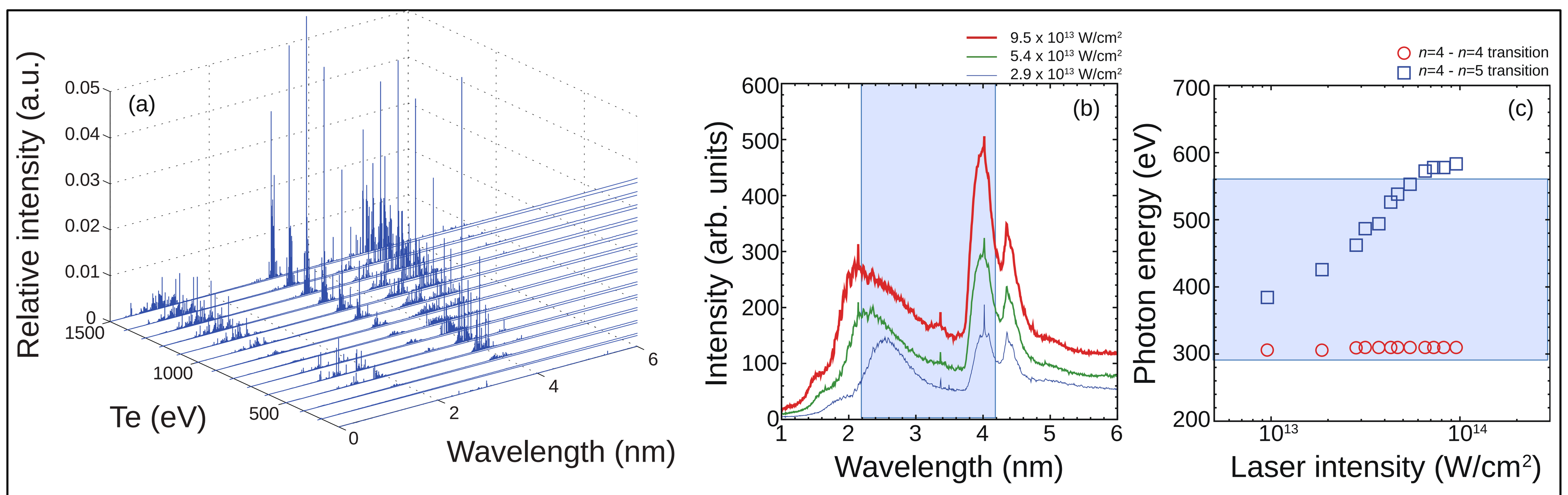


Fig. 2. (a) Calculated spectral variation as a function of electron temperature. Laser intensity dependence of the observed emission spectra of Bi plasmas (b), the peak wavelength of the n = 4−n = 4 transition (circles) and the n = 4−n = 5 transition (rectangles) (c).

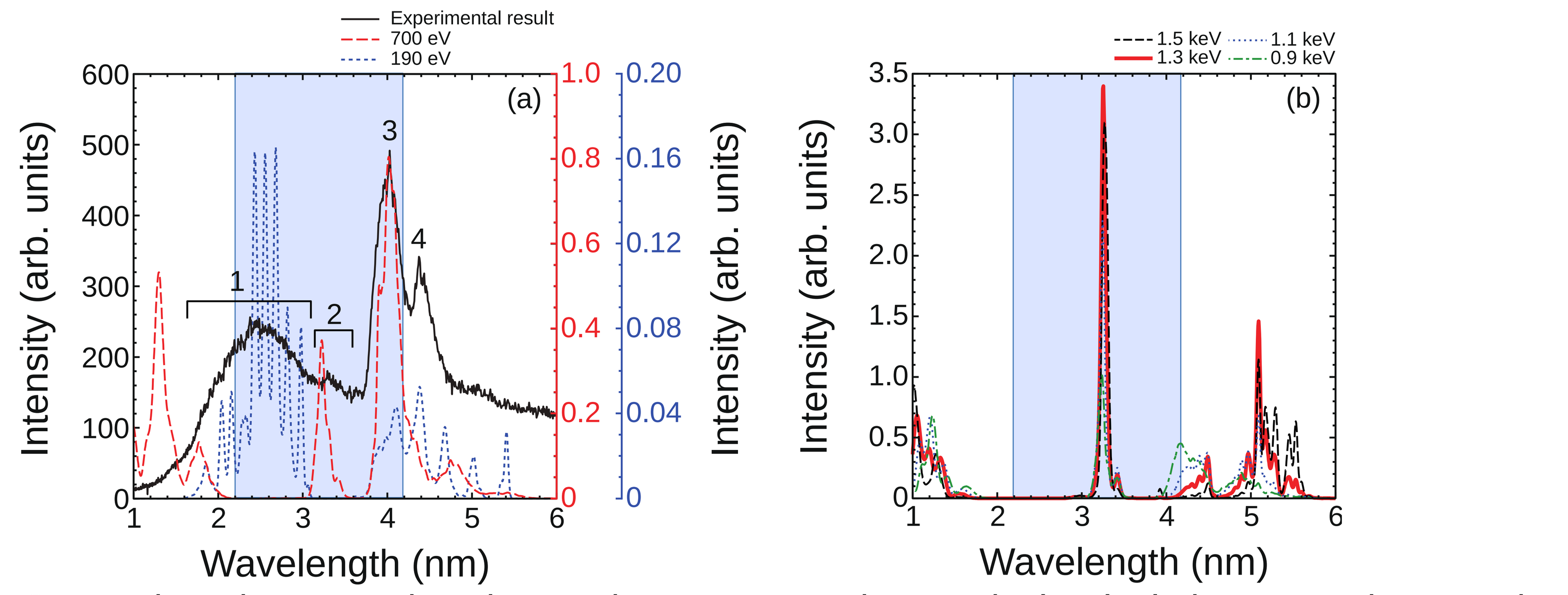
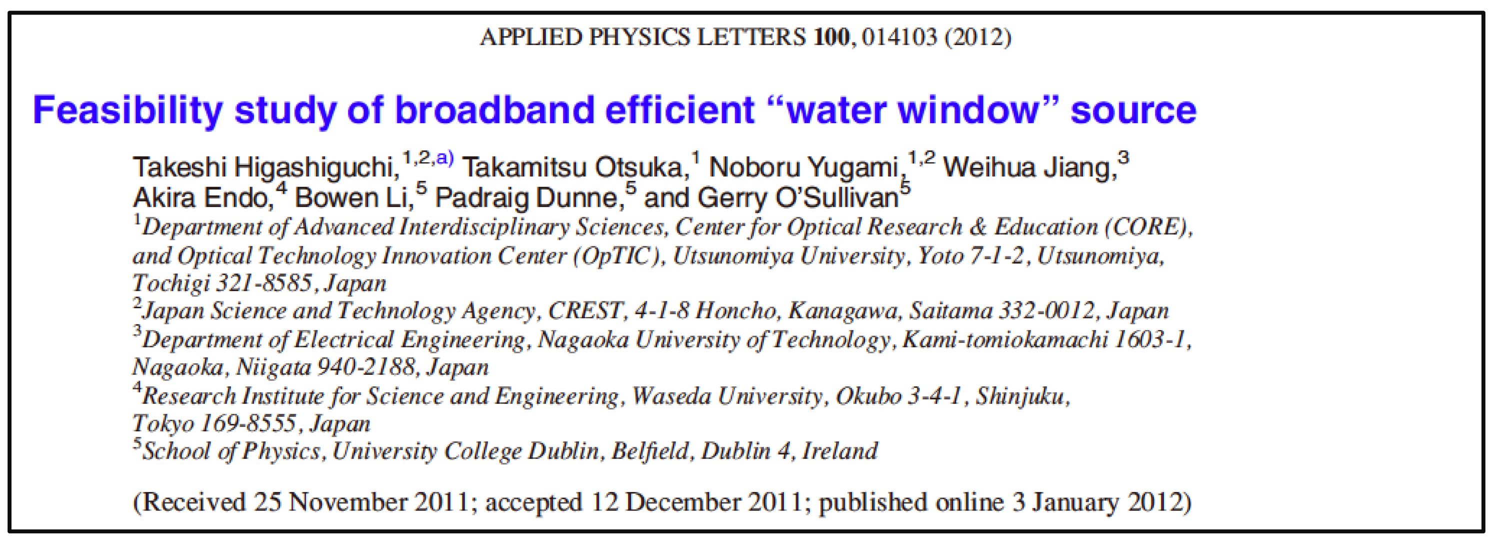


Fig. 3. (a) Comparison between the observed spectrum and numerical calculation assuming steady-state electron temperatures of 190 and 700 eV respectively. (b) Calculated spectra for electron temperatures higher than 900 eV.

3. Summary and Outlook

We have demonstrated a laser-produced plasma soft x-ray source in the water window spectral region using high-*Z* plasmas, including a numerical calculation of the potential of Bi plasma as a water window source for biological microscopy.

- We studied scaling of laser produced plasma UTA strong emission.
- We showed the possibility of n = 4−n = 4 UTA emission in the water window.
- Our calculations show that the electron temperature in a Bi plasma should be in the range from 0.6 to 1 keV, to radiate strongly near 3.1 and 3.9 nm.



APPLIED PHYSICS LETTERS **100**, 014103 (2012)

Feasibility study of broadband efficient "water window" source

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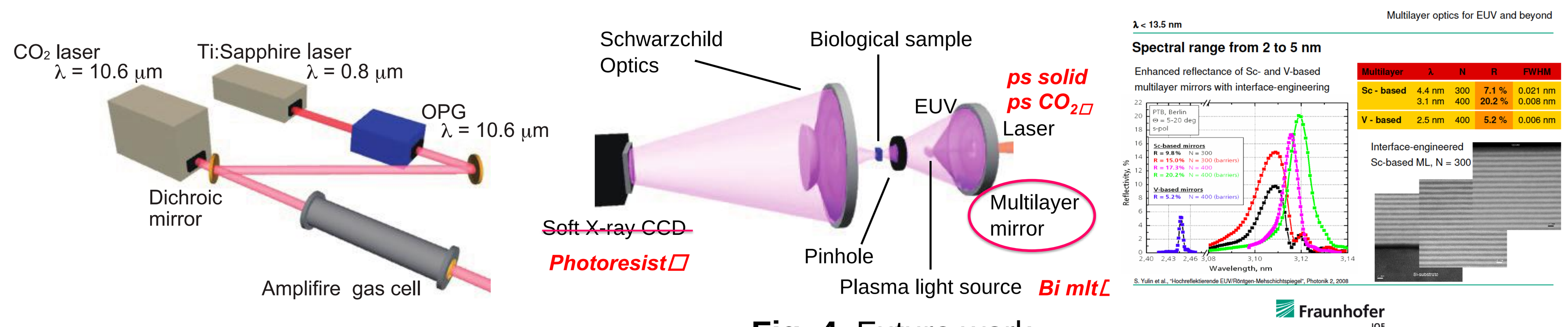

Fig. 4. Future work.

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